(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 911 493 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.04.1999 Bulletin 1999/17

(51) Int Cl.6: F01L 3/02, F01L 3/14,
F01L 3/20

(21) Application number: 98308461.7

(22) Date of filing: 15.10.1998

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 21.10.1997 US 955188

(71) Applicant: EATON CORPORATION
Cleveland, Ohio 44114-2584 (US)

(72) Inventor: Bonesteel, David Louis
Richland, Michigan 49083 (US)

(74) Representative: Burke, Steven David et al
R.G.C. Jenkins & Co.
26 Caxton Street
London SW1H 0RJ (GB)

(54) Improved tip structures for an ultra light engine valve

(57) An ultra light poppet valve (11) having increased stiffness at its tip end. The valve includes a stem (13) which is formed as a thin-walled, elongated cup member having a closed tip portion (19) and a flared open end (17). To which a disk-like cap member (15) is fixed. The stiffness of the tip is increased by various means including members (43;61) added to the tip portion (19), members (47;49) inserted within the tip portion, hard surfaces (53;53a) deposited on the tip portion, and members (43b;73) inserted within openings (71) in the end of the tip portion.

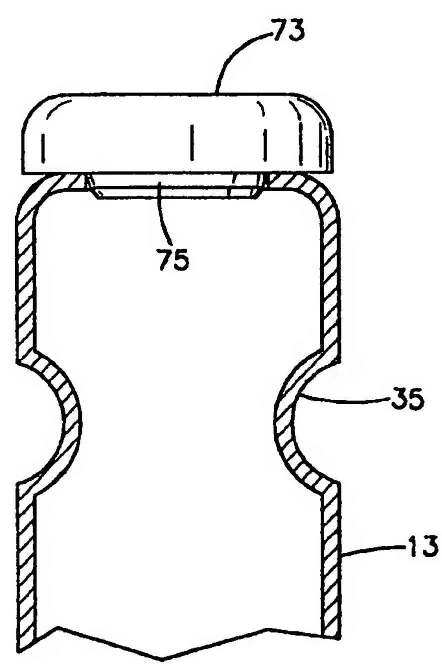

Fig.18

EP 0 911 493 A2

Printed by Jouve, 75001 PARIS (FR)

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

MICROFICHE APPENDIX

[0003] Not Applicable

BACKGROUND OF THE DISCLOSURE

[0004] The present invention relates generally to light weight poppet valves for internal combustion engines, and more particularly, to an improved engine valve having increased strength and stiffness at the tip portion of the valve.

[0005] Internal combustion engine poppet valves have been, and continue to be, fabricated by methods such as machining, forging, or extruding a sold blank of high strength, heat resistant metal, and then subjecting the blank to finish machining and/or grinding operations. In an effort to reduce the weight of the valves as much as possible, the stems of some valves are made hollow, and in some applications, performance requirements of the engine make it necessary to add a coolant, such as a sodium material, to the interior of the valve stem during the fabrication process.

[0006] In the prior art, such hollow stems have been formed by means such as drilling the stem, or by extruding or forging the stem over an mandrel or over a removable core. U.S. Patent No. 5,413,073, assigned to the assignee of the present invention and incorporated herein by reference, discloses a poppet valve which comprises a stem element including an integral tip and fillet portion, and a cap which is preferably welded to the stem element. The stem element is in the form of a "cup" having a flared open end defining the fillet region of the valve, and a closed end defining the tip portion. The stem element is hollow from the fillet region all the way to the tip portion, and the wall section of the stem element is relatively thick in the fillet region, then tapers down to a substantially uniform thickness for the rest of the length of the stem, but is again relatively thick at the tip portion. The stem element is fabricated by means of a deep drawing process, wherein a starting blank in the form of a sheet-like disc is subjected to a plurality of cold drawing steps which result in an elongated flared cup. The outer edge of the flared end and the tip portion are substantially of the thickness of the starting blank. One or more keeper grooves are typically rolled into the hollow stem, as an added step in the drawing process.

[0007] The tip of an internal combustion engine poppet valve is subjected to high contact forces and wear. The prior art teaches various structures and techniques for improving the wear resistance of the valve tip, including elements which are welded on to the tip end of the stem, as well as various other coatings and structures which are added to the tip end of the stem. However, the known prior art structures and techniques do not teach or suggest improvements in the strength and stiffness of the tip portion of a deep drawn, ultra light valve of the type to which the present invention relates.

BRIEF SUMMARY OF THE INVENTION

[0008] Accordingly, it is an object of the present invention to provide an improved ultra light poppet valve, and a method of making the same, including a tip construction wherein the tip portion is stronger and stiffer than known, prior art ultra light valves.

[0009] It is a related object of the present invention to provide an improved ultra light poppet valve wherein the load applied to the valve stem is isolated from the tip portion and/or the tip portion of the valve is stiffened to be able better to withstand loads applied by the valvetrain.

[0010] The above and other objects of the invention are accomplished by the provision of an ultra light poppet valve for an internal combustion engine comprising a stem portion, a cap portion, a tip portion, and a flared fillet portion defining a transition region between the stem portion and the cap portion. The cap portion comprises a disc-like cap member fixed to the fillet portion. The stem portion, the tip portion, and the fillet portion comprise a one-piece, thin-walled, deep-drawn member which is open at the fillet portion end thereof, and closed at the tip portion end thereof. The thin wall of the stem portion extends substantially the full length thereof.

[0011] The improved ultra light poppet valve is characterized by a member fixed relative to the closed tip portion, the member providing substantially greater stiffness to the tip portion.

[0012] In accordance with another aspect of the invention, a method is providing for manufacturing an ultra light poppet valve for an internal combustion engine. The poppet valve is of the type comprising a stem portion, a cap portion, and a tip portion, and a flared fillet portion defining a transition region between the stem portion and the cap portion.

[0013] The improved method comprises the steps of:

(a) providing a flat metal blank;

(b) subjecting the blank to a plurality of cold-forming steps wherein mandrels of decreasing diameter and increasing length are sequentially engaged with the blank to deep draw the blank into an elongated cylindrical stem portion having a substantially flat closed end comprising the tip portion, and a flared open end comprising the fillet portion.

(c) attaching said cap portion to the flared fillet por-

tion; and

(d) attaching to the tip portion a member operable to provide substantially greater stiffness to the tip portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a cross-sectional view of an ultra light engine poppet valve of the type to which the present invention relates.

[0015] FIG. 2 is an enlarged, fragmentary, cross-sectional view of the tip portion of the valve of FIG. 1.

[0016] FIGS. 3A through 3D are somewhat schematic sectional views representing the various steps in the fabrication of the stem portion of the poppet valve shown in FIG. 1.

[0017] FIG. 4 is a fragmentary, cross-sectional view showing a method of forming a keeper groove in the stem portion of the poppet valve of FIG. 1.

[0018] FIG. 5 is a sectional view taken on line 5-5 of FIG. 4.

[0019] FIG. 6 through 9 are fragmentary, cross-sectional views of the tip portions of poppet valves made in accordance with the present invention.

[0020] FIGS. 10 and 11 are fragmentary, cross-sectional views of alternative embodiments of the present invention.

[0021] FIG. 12 is a fragmentary cross-sectional view of another alternative embodiment of the tip portion of the present invention.

[0022] FIGS. 13 and 14 are fragmentary, cross-sectional views of still another alternative embodiment of the invention.

[0023] FIGS. 15 and 16 are fragmentary, cross-sectional views of another alternative embodiment of the present invention.

[0024] FIGS. 17 and 18 are fragmentary, cross sectional views of a valve tip, and the method of assembly thereof, of one final embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Referring now to the drawings, which are not intended to limit the invention, FIG. 1 illustrates a prior art ultra light valve (ULV) for use as an engine poppet valve, generally designated 11, comprising a stem element 13, and a cap element 15, which is welded or otherwise joined to the stem element 13. In the preferred embodiment, the stem element 13 for an intake valve can be fabricated using a ductile metal sheet product, such as SAE 1008 Steel, while the stem element for an exhaust valve can be fabricated using a stainless steel, such as UNS 305 or Incoloy 800. The cap element 15 can be formed of a stainless steel, or other compatible material, in either case. It will be appreciated by those skilled in the art that the specific materials will vary depending upon the engine application.

[0026] As will be described in greater detail subsequently, the stem element 13 is formed by a deep drawing process which results in a first wall thickness T1 in the region of a fillet portion 17, the wall thickness being at a maximum at the outer extremity of the fillet portion 17. The stem element 13 is at a second thickness T2, which is less than T1, throughout the length of the stem. Finally, the stem element 13 is at a third thickness T3 at a tip portion 19, T3 being approximately the same thickness as T1.

[0027] In the prior art version of FIG. 1, the tip portion 19 is shown as being "squared off", but in FIG. 2, there is illustrated an alternative design for the tip portion 19, wherein there is a bevel 21. It has been known in the prior art to include the bevel 21 in an effort to increase the stiffness of the tip portion 19 of the poppet valve 11. In the example illustrated in FIG. 2, the bevel is preferably formed at an angle of about 40 degrees.

[0028] The cap element 15 is a disc which is preferably formed with a convex combustion face 23, and a concave internal face 25, the cap 15 being welded to the stem element 13 at a weld joint 27. The weld joint 27 forms no part of the present invention, is generally known to those skilled in the art, and will not be described further herein. A seat face 29 can be formed by machining, by deposition and machining, or by other known methods. The stem element 13 is formed by means of a cold forming process known as deep drawing, which is typically carried out on a type of transfer press. In this process, a series of drawing steps is carried out on a work piece which starts out as a flat sheet or disc, and which is stepwise transferred from one set of drawing tools to another, with a plurality of the steps being carried out within a single transfer press, but with each of the steps being individually cam operated. The result of this process is the transformation of the flat disc into an elongated, cylindrical, deep drawn cup member which is formed to near net dimensions, and is of exceptional straightness. The process is capable of producing parts which have exceptionally thin walls, but wherein the part is of relatively high strength, because of the cold working of the material which occurs during the deep drawing process.

[0029] Referring now primarily to FIGS. 3A through 3D, there is a schematic illustration of several representative, typical steps in the deep drawing process, which starts with a flat disc 13A in FIG. 3A, and progresses through a number of intermediate steps as illustrated in FIGS. 3B through 3D, wherein the flat disc 13a is progressively transformed as described previously through the different shapes, labeled 13b, 13c and 13d, respectively. The work piece is held in fixtures 31b, 31c and 31d, while cam-actuated plungers or mandrels 33b, 33c, and 33d, respectively are engaged with the work piece, to deep draw it to the desired shape. Additional steps needed to trim the open flared end around the fillet portion 17, and to true the radius of the fillet portion 17, etc.

can also be achieved in the course of or after completion of the drawing process. A further pressing operation may also be carried out to insure that the tip portion 19 is in its desired, final shape, if for example, the tip portion 19 is to be configured as shown in FIG. 2. Referring now primarily to FIGS. 4 and 5, a keeper groove 35 is preferably formed as a part of the cold forming process. In this step, the work piece (simply identified as the stem element 13) in its nearly completed form is transferred to a station wherein it is received between two dies 37 and 39.

[0030] The dies 37 and 39 are geared, or otherwise linked together, to move in opposite directions, as indicated by the arrows in FIG. 5, and to roll the work piece 13 between them. To form the groove 35, the die 37 has a knurled or other high-friction surface 37a formed thereon to grip the work piece, and the die 39 has a projection 39a thereon in the form of a ramp to displace the material of the work piece wall to form the keeper groove 35. Other methods of forming the keeper groove can also be used, but because of the displacement of material during the formation of the keeper groove 35, the final steps to insure the shape of the tip portion 19, and to obtain the final dimensions of the stem portion 13, are carried out after the step of rolling the keeper groove 35. A single groove is shown herein but it will be understood by those skilled in the art that multiple grooves of various shapes can be formed if required for a particular engine design, or to provide additional stiffness in that portion of the stem element 13.

[0031] The final stem element 13 which results from the above-described process is characterized by an integral tip portion 19, and by a very thin wall throughout the length of the straight part of the stem, but wherein the thicknesses T1 and T3, in the areas of the fillet portion 17 and of the tip portion 19, respectively, are essentially the thickness of the original sheet metal disc 13a of FIG. 3A.

[0032] FIGS. 6 through 18 disclose various means, in accordance with the present invention, for isolating valve train loads from the tip end of the above-described valve design, and/or for significantly stiffening the tip end of the valve. References herein and in the appended claims to the thin-walled, deep-drawn member being closed at the tip portion, or similar references, will be understood to mean that the tip portion is closed during at least some point in the process of forming the valve, the stem and the tip portion. However, the references to the tip portion being closed do not necessarily require that the original tip portion, which is part of the deep-drawn stem, remain intact. In certain embodiments, the original tip portion may be pierced, or cut off, to define an opening, after which a member is inserted into the opening, such that the final configuration of the tip portion is closed. This point will become clearer upon a reading of the remainder of the specification.

[0033] Referring now primarily to FIGS. 6 through 9, FIG. 6 shows a valve stem 13 wherein the tip is formed into a concave shape 41 to which is assembled a hardened spherical member 43. The member 43 has a flat contact surface 45 formed thereon, to form a ball and socket connection which is retained by means of a clip 47. The member 43 is preferably formed of a through hardened, alloyed carbon steel, while the clip 47 can be formed of steel or of a plastic material, such as nylon.

[0034] The embodiment of FIG. 7 is similar to that shown in FIG. 6, except that the ball and socket connection is formed by forming the tip of the valve stem 13 into a convex shape 41a, and the hardened spherical member 43a with a mating concave surface formed thereon.

[0035] FIGS. 8 and 9 represent variations of the concept shown in FIGS. 6 and 7, wherein a ball 43b, which can be an off-the-shelf bearing ball, is welded to the end of the stem 13, and more specifically, to a concave shape 41 as in FIG. 6. A portion of the ball is subsequently ground off to form the contact surface 45. The FIG. 8 embodiment thus corresponds to the FIG. 6 embodiment. However, the FIG. 9 embodiment differs from that of FIG. 7 in that the end of the valve stem 13 is either pierced in the cold forming process, to form an open tube, or is cut off afterward. The FIG. 9 embodiment is similar to the FIG. 8 embodiment in regard to the use of the bearing ball 43b, which is welded to the open end of the valve stem 13, and the subsequent grinding off of part of the ball to form the contact surface 45.

[0036] FIGS. 10 and 11 illustrate embodiments wherein the tip end of the valve stem 13 is stiffened by the addition of a plug, between steps of the cold forming process. In FIG. 10, a plug 47 is preferably formed of a light metal, such as aluminum, and can be of a length just sufficient to be retained by the deflection of the stem material, during the rolling of the keeper groove 35. Alternatively, the plug 47 could have a length sufficient to span the deflected area (as shown for the FIG. 11 embodiment), to provide additional stiffness at the tip end of the valve. FIG. 11 illustrates the use of a plug 49 which is formed of a metallic sponge material, and which is also retained by the process of rolling the keeper groove 35. The plug 49 performs a function similar to that of the plug 47 in the FIG. 10 embodiment, but the plug 49, being of a sponge-like construction, would typically weigh less than the solid plug 47. Both FIGS. 10 and 11 show a tip end 19 having the general configuration shown in FIG. 2, although it will be appreciated that the tip end could also be formed as shown in FIG. 1.

[0037] Referring now to FIG. 12, there is illustrated an embodiment in which stiffness is added to the tip end by forming a rib 51, which may be formed initially by rolling, in a manner similar to the forming of the keeper groove 35, with the rib 51 then being flattened against the end of the valve stem 13 in the manner shown.

[0038] FIGS. 13 and 14 show embodiments wherein a wear surface is formed on the tip end 19 of the valve stem 13 by metal deposition. In the FIG. 13 embodiment, a metal layer 53 is deposited over the flat tip 19, while in the FIG. 14 embodiment, a depression 55 is

formed at the tip end, and a metal layer 53a is formed in the depression. The metal layers 53 and 53a are preferably formed of a hard material, suitable for use as a valve seat facing, such as a Stellite 6. The material can be melted onto the surface of the tip by any one of several known hard facing processes, using carbon arc, TIG, laser, or plasma transferred arc as a heat source.

[0039] In the embodiments shown in FIGS. 15 and 16, the end area of the tip is necked down in the cold forming process, and a hardened cap is positioned over the necked down portion. In FIG. 15, a cap 61 is welded by means of a friction, resistance, or laser weld process over a necked down portion 63. In FIG. 16, the keeper groove 35 is formed after a cap 61b is assembled over a longer necked down portion 63b. The deflection resulting from the formation of the keeper groove 35 also serves to retain the cap 61b on the necked down portion. In both the FIG. 15 and 16 embodiments, the cap is preferably formed of a hardened alloyed medium carbon steel.

[0040] Finally, FIGS. 17 and 18 illustrate an embodiment in which, like FIG. 9, the end of the valve stem 13 is pierced to define a temporary opening 71. Also provided is a tip wafer 73 which is a plug-like member including a generally conical, reduced diameter portion 75, which may be just slightly larger in diameter than the opening 71. As is shown in FIG. 18, the tip wafer 73 may be put in place, with the reduced diameter portion 75 lightly pressed into the opening 71, and subsequently, the tip wafer 73 may be welded, such as by friction welding, to the tip end of the valve stem 13. Preferably, pressing the wafer 73 into the opening 71 will somewhat deform the tip end so that there is greater area of engagement between the underside of the wafer 73 and the adjacent surface of the tip end, to facilitate the welding process.

[0041] One advantage of the embodiment of FIGS. 17 and 18 is that the construction shown makes it possible to weld the cap 15 onto the fillet portion 17 before filling the valve stem 13 with the appropriate coolant, such as a sodium material. As is well known to those skilled in the art, it is desirable not to subject the coolant material to excessive heat generation, and the welding of the cap 15 onto the fillet portion 17 generates substantially greater heat than does the welding of the tip wafer 73 onto the end of the valve stem 13. Therefore, in accordance with one aspect of the invention, after welding the cap 15 onto the fillet portion 17, and filling the valve stem with coolant, the tip wafer 73 is inserted and then the weld bead 77 formed, thus sealing the coolant within the valve stem 13.

[0042] As a further alternative to the embodiment of FIGS. 17 and 18, the wafer 73 could be replaced by an axially longer plug member. In that case, it is likely that the plug member would define the required keeper groove, rather than having it formed in the deep-drawn stem. Also, the outside diameter of the reduced diameter portion 75 could be substantially equal to the inside diameter of the stem element 13, rather than having the diameter of the opening 71. It will be understood by those skilled in the art that various other combinations of the individual features disclosed herein are possible, within the scope of the present invention. The essential feature of the invention is the provision, in a ULV, as that term has been define hereinabove, of structure which provides substantially greater stiffness to the tip portion.

[0043] The invention has been described in great detail in the foregoing specification, and it is believed that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims.

Claims

1. An ultra light poppet valve (11) for an internal combustion engine comprising a stem portion (13), a cap portion (15), a tip portion (19), and a flared fillet portion (17) defining a transition region between said stem portion (13) and said cap portion (15); said cap portion comprising a disc-like cap member fixed to said fillet portion (17); said stem portion (13), said tip portion (19), and said fillet portion (17) comprising a one-piece, thin-walled, deep-drawn member which is open at the fillet portion (17) end thereof, and closed at the tip portion (19) end thereof, the thin wall of the stem portion (13) extending substantially the full length thereof, characterized by:

   (a) a member (43;47;49;51;53;61;73) fixed relative to said closed tip portion (19), said member providing substantially greater stiffness to said tip portion (19).

2. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member (43;51;53;61;73) being fixed to the exterior of said tip portion (19).

3. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member (47;49) being disposed within the interior of said tip portion (19).

4. An ultra light poppet valve (11) as claimed in claim 1, characterized by said tip portion (19) having a concave surface (41) formed thereon, and said member (43;43b) fixed to said tip portion comprises a substantially spherical element in contact with said concave surface, and having a flat face (45) formed on the outer surface thereof.

5. An ultra light poppet valve (11) as claimed in claim 1, characterized by said portion (19) having a con-

vex surface (41a) formed thereon, and said member (43a) fixed to said tip portion comprises a substantially spherical element in contact with said convex surface, and having a flat face (45) formed on the outer surface thereof.

6. An ultra light poppet valve (11) as claimed in any one of claims 4 or 5, characterized by said member (43;43a;43b) being welded to said surface (41;41a).

7. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member comprises a plug member (47;49) inserted into said stem portion (13) prior to formation of a keeper groove (35), said plug member (47;49) being retained in engagement with the interior of said tip portion (19) by the inward deformation resulting from the formation of said keeper groove (35).

8. An ultra light poppet valve (11) as claimed in claim 1, characterized by said plug member (47) being formed of a solid metallic material.

9. An ultra light poppet valve (11) as claimed in claim 1, characterized by said plug member (49) being formed of a metallic sponge material.

10. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member (51) comprises a substantially double layer of the material of said tip portion (19).

11. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member comprising a layer of metallic material (53;53a) deposited on said tip portion (19).

12. An ultra light poppet valve (11) as claimed in claim 11, characterized by a depressed surface (55) being formed in said tip portion (19), and said layer of metallic material (53;53a) being deposited on said depressed surface (55).

13. An ultra light poppet valve (11) as claimed in claim 1, characterized by said member comprises a substantially cup-shaped cap member (61;61b) received over said tip portion (19).

14. An ultra light poppet valve (11) as claimed in claim 13, characterized by an area of said stem portion (13) being formed at a reduced diameter, said cap member (61;61b) being received over said area of reduced diameter.

15. An ultra light poppet valve (11) as claimed in claim 14, characterized by said cap member (61) being welded to said stem portion (13).

16. An ultra light poppet valve (11) as claimed in claim 14, characterized by a circumferential groove being formed in said cap member (61b) by deforming a portion of said cap member inwardly after said cap member is received over said area of reduced diameter, said cap member (61b) being retained on said stem portion (13) by said inward deformation.

17. An ultra light poppet valve (11) as claimed in claim 1, characterized by an opening (71) being formed in said tip portion (19), and said member (43b;73) is located at least partially within said opening.

18. An ultra light poppet valve (11) as claimed in claim 17, characterized by said member comprises a plug-like member (73) including a reduced diameter portion (75) which is received within said opening (71).

19. An ultra light poppet valve (11) as claimed in claim 17, characterized by said said member (43b;73) being welded within said opening (71) in said tip portion (19).

20. A method of manufacturing an ultra light poppet valve (11) for an internal combustion engine, the poppet valve being of the type comprising a stem portion (13), a cap portion (15), a tip portion (19), and a flared fillet portion (17) defining a transition region between said stem portion (13) and said cap portion (15); the method comprising the steps of:

(a) providing a flat metal blank (13a);
(b) subjecting said blank (13a) to a plurality of cold forming steps wherein mandrels (33) of decreasing diameter and increasing length are sequentially engaged with said blank (13a) to deep draw said blank into an elongated cylindrical stem portion (13) having a substantially flat closed end comprising said tip portion (19), and a flared open end comprising said fillet portion (17);
(c) attaching said cap portion (15) to said flared fillet portion (17); and
(d) attaching to said tip portion (19) a member (43;47;49;51;53;61;73) operable to provide substantially greater stiffness to said tip portion (19).

21. A method as claimed in claim 20, characterized by the additional step of introducing into said cylindrical stem portion (13) a quantity of cooling medium.

22. A method as claimed in claim 20, characterized by said step of introducing said cooling medium occurs after the step of attaching said cap portion (15), and before the step of attaching to said tip portion (19) said member (73) providing greater stiffness.

23. A method as claimed in claim 20, characterized by said step of attaching to said tip portion (19) said member (43;51;53;61;73) providing greater stiffness comprises attaching said member to the exterior of said tip portion.

24. A method as claimed in claim 20, characterized by said step of attaching to said tip portion (19) said member (49) providing greater stiffness comprises attaching said member within the interior of said tip portion (19).

25. A method as claimed in claim 20, characterized by said step of attaching to said tip portion (19) said member (73) providing greater stiffness comprises, after subjecting said blank (13a) to a plurality of cold forming steps:

(e) forming an opening (71) in said tip portion (19);
(f) inserting into said opening (71) from the exterior of said tip portion (19) said member (73) providing greater stiffness; and
(f) attaching said member (73) to said tip portion (19).

26. A method as claimed in claim 25, characterized by said step of inserting said member (73) providing greater stiffness occurs after the step of attaching said cap portion (15).

27. A method as claimed in claim 26, characterized by the additional step of introducing into said cylindrical stem portion (13) a quantity of cooling medium, after the step of attaching said cap portion (15), but before the step of inserting and attaching said member (73).

28. A method as claimed in claim 27, characterized by said step of attaching said member (73) providing greater stiffness to said tip portion (19) comprises welding said member (73) to said tip portion (19) about substantially the entire circumference thereof.

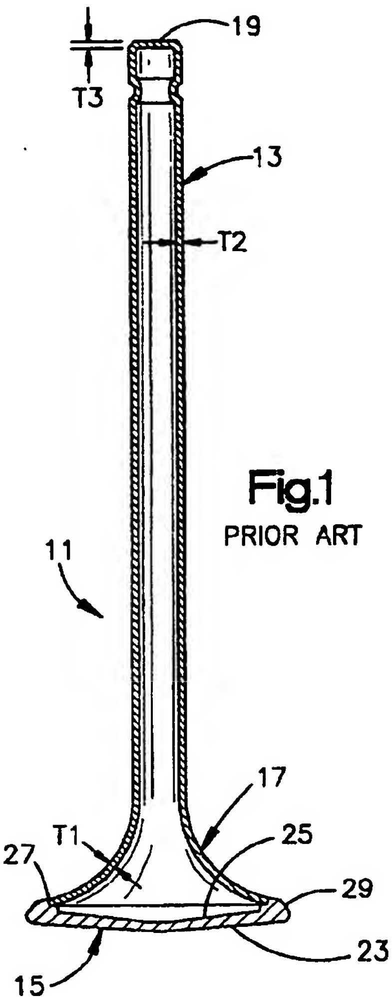

Fig.1
PRIOR ART

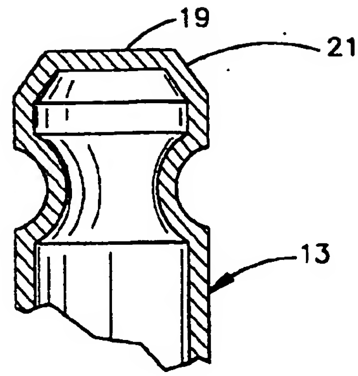

Fig.2
PRIOR ART

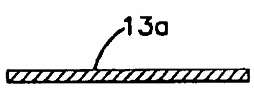

Fig.3A

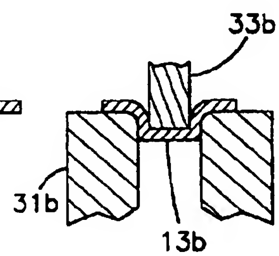

Fig.3B

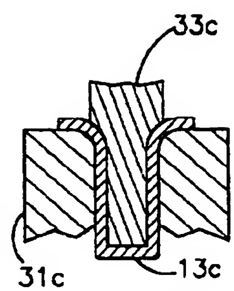

Fig.3C

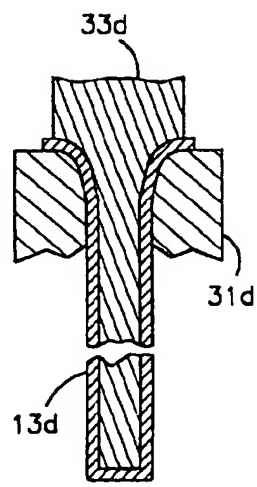

Fig.3D

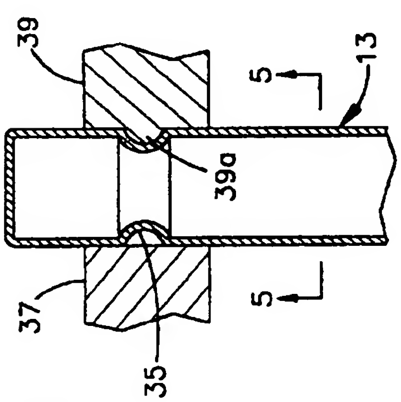

Fig.4

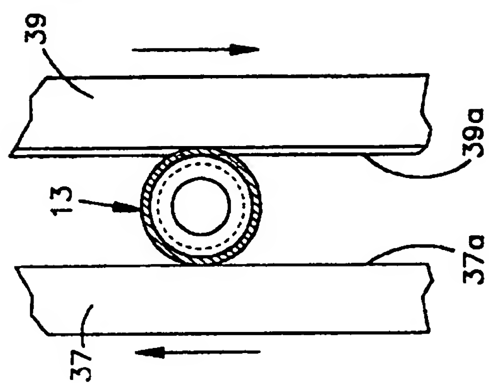

Fig.5

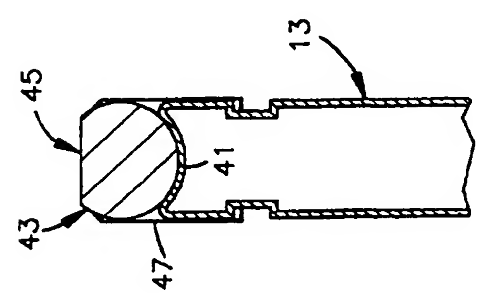

Fig.6

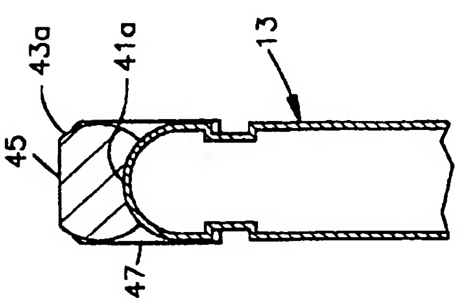

Fig.7

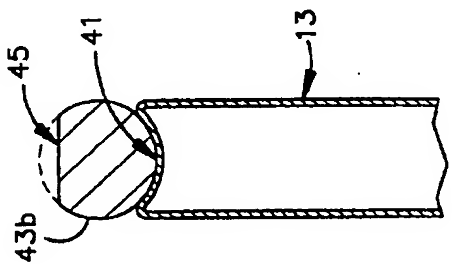

Fig.8

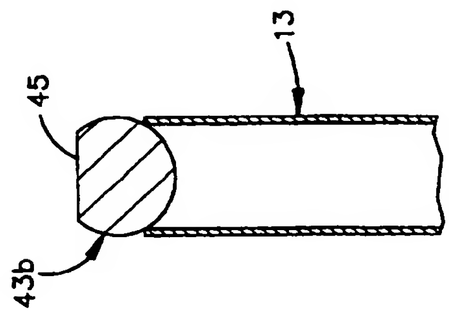

Fig.9

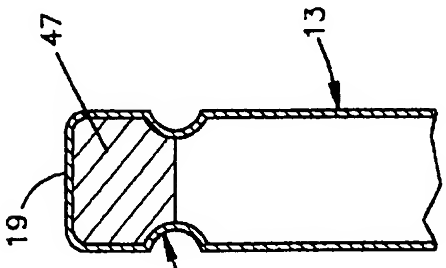

Fig.10

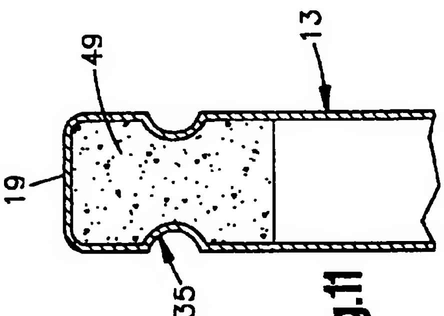

Fig.11

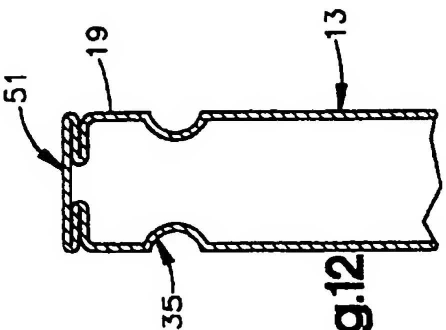

Fig.12

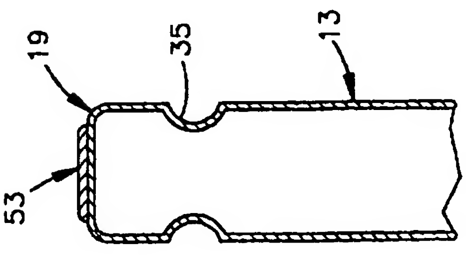

Fig.13

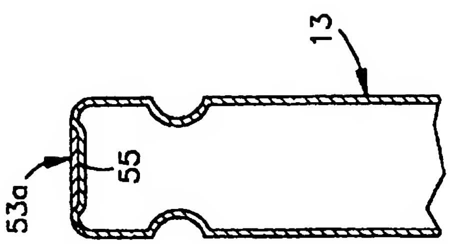

Fig.14

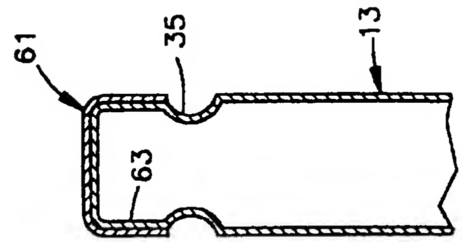

Fig.15

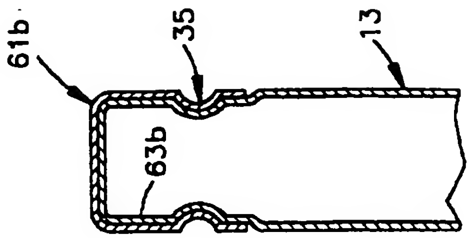

Fig.16

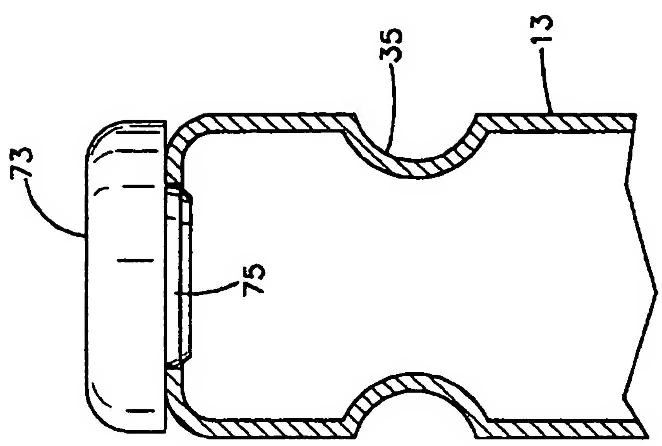

Fig.18

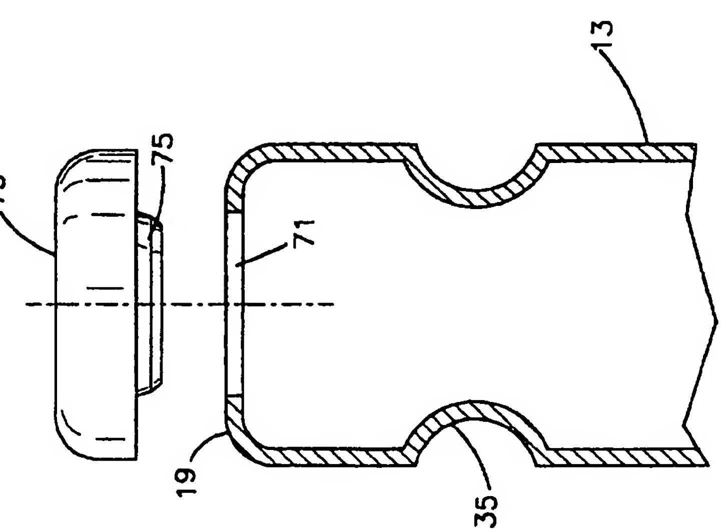

Fig.17